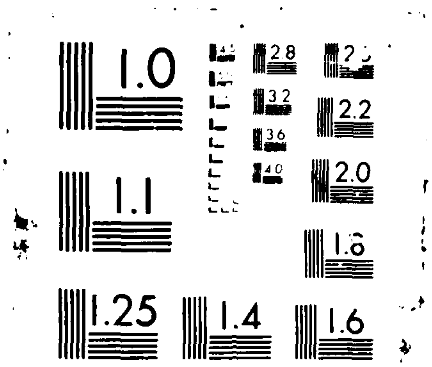
AD-A178 111 RECOGNITION OF VISUAL LETTER STRINGS FOLLOWING INJURY 1/1
TO THE POSTERIOR VISUAL SPATIAL ATTENTION SYSTEM(U)
WASHINGTON UNIV ST LOUIS MO E SIEROFF ET AL. 30 DEC 86
UNCLASSIFIED N00014-86K-0289 F/G 5/10 NL


1.0
2.8
2.2
3.2
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6

SECURITY CLASSIFICATION OF THIS PAGE

(12)

REPORT DOCUMENTATION PAGE

AD-A178 111

DTIC ELECTE 9 1987 D

1b RESTRICTIVE MARKINGS

3 DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
Technical Report #3

5 MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
Washington Univ. Sch. of Med.
Department of Neurology

6b. OFFICE SYMBOL *(If applicable)*

7a. NAME OF MONITORING ORGANIZATION
Personnel & Training Programs
Office of Naval Research

6c. ADDRESS (City, State, and ZIP Code)
660 S. Euclid, Box 8111
St. Louis, MO 63110

7b ADDRESS (City, State, and ZIP Code)
800 N. Quincy St.
Arlington, VA 22217-5000

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL *(If applicable)*

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
N0014-86-K-0289

8c. ADDRESS (City, State, and ZIP Code)

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
61153N	RR04206	RR04206-0A	NR442a554

11 TITLE *(Include Security Classification)*
Recognition of Visual Letter Strings Following Injury to the Posterior Visual Spatial Attention System.

12 PERSONAL AUTHOR(S)
Eric Sieroff, Alexander Pollatsek, Michael I. Posner

13a. TYPE OF REPORT Technical

13b. TIME COVERED FROM 01MAY86 TO 01MAY87

14 DATE OF REPORT *(Year, Month, Day)* 12/30/86

15 PAGE COUNT [illegible]

16. SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
[illegible]	[illegible]	

18 SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
Recognition, Visual Letter Strings, Posterior Visual Spatial Attention System

19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*

Unilateral posterior lesions often produce a deficit in visual spatial attention. The result of this deficit is a loss of information from a word contralateral to the lesion when presented simultaneously with an ipsilateral word (interword extinction). However, when a single word presented at fixation covers the same visual angle there is frequently no extinction (SIEROFF & MICHEL, in press). Why are centered words not extinguished? Our studies attempt to discover the reason by comparing centered word and nonword letter strings. Nonwords do show extinction. Words are processed more accurately and show little evidence of extinction. Compound words appear to act like normal words, but segmenting letters into separate strings increases extinction.

These results suggest that spatial attention is unnecessary for access to the [illegible] that produces a visual word form.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT
☐ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION

22a NAME OF RESPONSIBLE INDIVIDUAL

22b TELEPHONE *(Include Area Code)*

22c OFFICE SYMBOL

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

DTIC FILE COPY

Recognition of Visual Letter Strings Following

Injury to the Posterior Visual Spatial Attention System

Eric Sieroff[1], Alexander Pollatsek[2], and Michael I. Posner[3]

[1]Now at Laboratoire de Neuropsychologie, Hospital Neurologique, Lyon, France,

[2]University of Massachusetts, Amherst, [3]Washington University, St. Louis

ONR 87-3

Research sponsored by: Personnel and Training Research Program
Psychological Sciences Division
Office of Naval Research

Under Contract Number: N0014-86-K-0289
Contract Authority Number: NR-442a554

87 3

Recognition of Visual Letter Strings Following Injury to the Posterior Visual Spatial Attention System[1]

Eric Sieroff*[2], Alexander Pollatsek** and Michael I. Posner***

Abstract

Unilateral posterior lesions often produce a deficit in visual spatial attention. One result of this deficit is a loss of information from a word contralateral to the lesion when presented simultaneously with an ipsilateral word (interword extinction). However, when a single word presented at fixation covers the same visual angle there is frequently no extinction (SIEROFF & MICHEL, in press). Why are centered words not extinguished? Our studies attempt to discover the reason by comparing centered word and nonword letter strings. Nonwords do show extinction. Words are processed more accurately and show little evidence of extinction. Compound words appear to act like normal words, but segmenting letters into separate strings increases extinction.

These results suggest that spatial attention is unnecessary for access to the lexical network that produces a visual word form.

*Departments of Neurology and Neurological Surgery and McDonnell Center for Higher Brain Function, Washington University, St. Louis

**Department of Psychology, University of Massachusetts, Amherst

***Departments of Neurology and Neurological Surgery and McDonnell Center for Higher Brain Function, Washington University, St. Louis

Introduction

Cognitive psychologists have been interested in the superiority of words over nonwords in a variety of perceptual tasks. According to some theories the visual word attains an integrated word form within the visual system that allows access to phonological and semantic processors (COLTHEART, DAVELAAR, JONASSON, BESNER, 1979). It is often suggested that the letters of familiar words are integrated without any active scanning or attentional process but rather automatically look up their phonological and semantic codes (LABERGE & SAMUELS, 1974, POSNER, 1978).

Cognitive Neuropsychology tries to relate information processing models to brain structure. One way to approach this relationship has been through understanding deficits when there is a brain lesion. A number of clinical syndromes involving perception of words have been described (BENSON & GESCHWIND, 1969). Some of these appear to be the result of a deficit in spatial attention. For example, patients with right-sided lesions who have no general language deficit often fail to perceive the start of written sentences or words. Not all of these effects are due to sensory problems because they may occur even when the word is presented in the good visual hemifield (KINSBOURNE & WARRINGTON, 1962).

Previous work (FRIEDRICH, WALKER & POSNER, 1985) has shown that patients with spatial attention deficits who were required to search letter or word strings for a mismatching letter pair showed profound effects on reaction time. Patients with right-sided lesions are actually slower to find a mismatch at the start of the string than at the end. These effects do not differ between conditions in which subjects are allowed to move their eyes and ones in which they are presented with tachistoscopic information (POLLATSEK, WALKER, FRIEDRICH & POSNER, 1985). However, it has been found (SIEROFF & MICHEL, in press) that reading single words centered on the fovea is most often spared from the effect of parietal lesions. In this work, tachistoscopic presentation of single unilateral words, simultaneous bilateral words, and centered words were compared in patients with cerebral lesions. The same visual angle was covered by the stimulus in all conditions. Nonetheless, most patients with profound impairment in the simultaneous bilateral condition (extinction phenomenon) showed no impairment with centered words. The concept emerging from this work (SIEROFF & MICHEL, in press) is that the creation of the "word form" (WARRINGTON & SHALLICE, 1980.) is spared from the attentional scanning deficit produced by parietal lesions.

One possibility is that the physical continuity of a word string centered on the fovea is the reason for the sparing of words from extinction. The physical unity of the stimulus might avoid any need for letter by letter scanning. Another possibility is that the facilitation for words occurs because the stimulus corresponds to a unit already stored in our memory. In the interactive activation model of McCLELLAND & RUMELHART (1981, RUMELHART & McCLELLAND, 1982), early visual information activates high level word forms which feed back to facilitate the individual letters. If physical continuity results in sparing of centered words, presentation of a centered word or of a centered meaningless string of letters should give similar results. If words are spared because of an interactive activation, identification of the side contralateral to the lesion should be much worse for a centered non-word than for a word.

The current study compares perception of words and nonword letter strings by patients with known deficits in visual spatial attention. We find that, despite the severe deficit of these patients in exploring and processing visual stimuli, the reading of words is much superior to reading simple strings of letters. The first experiment involves 8 such patients who were well past the lesion and were presented stimuli tachistoscopically. The second experiment involves 10 patients shortly after the lesion who were given a bedside test in which they were required to read letter strings from cards. The third experiment compares the respective importance of lexical and physical unity.

Experiment 1

Tachistoscopic Tests

In Experiment 1 we tested eight patients with parietal damage. Many of them showed no or minimal clinical neglect at the times of testing. All but two had demonstrated deficits of spatial attention, and particularly problems with disengaging attention from a cue ipsilateral to the target they were required to detect (see POSNER, WALKER, FRIEDRICH & RAFAL, 1984). In addition, none of the subjects had a visual field deficit in the area in which the stimuli were presented.

The use of these subjects (who were all outpatients) allowed us to employ brief (100 ms) presentations of words and nonwords that precluded eye movements. Thus, the deficits observed relative to both normal subjects and relative to subjects with lesions in the opposite hemisphere could more reliably be attributed to problems in covert attention rather than with problems in eye movement guidance.

Subjects

The subjects were five patients with right parietal lesions, three patients with left parietal lesions and five normal subjects. The normal subjects were not matched on age with the two parietal groups, but were included to confirm the usual differences in identification of words and nonwords under our exposure conditions. The description of the parietal patients is in Table 1. The scale of the severity of the neglect is the same as the one used by POSNER, et al., (1984).

INSERT TABLE 1

Methods

The subjects' task was to identify the string of letters that appeared on the screen for 100 ms. The stimuli were centered around the fixation point and were composed of upper case letters. Half were words and half were nonwords, and in each group, one third were four letters, one third were five letters and one third were six letters. The letters subtended about 2-4^{o} horizontally. The nonwords were almost all nonpronounceable. The subjects were informed that some of the strings would not be words and were told to report the string in any way that they could. Subjects usually (but not always) reported the words by saying the word name and the letter strings by reporting the letter names in a left-to-right order.

The experimenter began a trial by saying "Ready?" and then pressed a key to present the letter string. There was a delay of 1000 ms between the lever push and the onset of the letter string. The responses were not timed, and the experimenter transcribed the subject's response. The session was recorded on audio tape and the tape was consulted in case of any uncertainty in recording the subject's reponses. A trial block consisted of 54 words and 54 nonwords presented in a random order, most subjects had two trial blocks, each in a different session. The normals and patients RF, FR and CU had only one block. Each trial block lasted about 30 to 45 minutes.

Results and Discussion

The subjects' responses were recorded by the experimenter during the session and the transcriptions checked by examining the audio recording. In the initial scoring of the error data, transcriptions of a subject's protocols were examined, and each letter was scored as to whether it was correctly reported or not. A strict scoring procedure was used (i.e., letters were counted as being correct only if they were in the proper position) with the following exception: when the subject reported fewer letters than were presented, the scorer would insert blanks between, before, or after the letters reported so as to give the subject the highest possible score (i.e., the subject was given all benefits of doubt on the missing letters). Strings in which more letters were reported than were presented were also scored for insertion errors between two letters. (These errors were relatively rare and easy to score for position since there were usually few other mistakes on those strings.) Two scorers independently scored the data and their agreement was well over 90%. They then adjudicated disagreements (most of which were clerical errors in scoring).

The scoring procedure seems fairly neutral with respect to the position of errors. The lenience of the procedure when there were missing letters should help to minimize counting correctly perceived letters at the end as "end errors" due to being reported out of position. While this scoring system like most, is still likely to exaggerate the number of "end errors" (as end letters will be reported out of position more than beginning letters), this bias will be the same for all subject populations and should not affect group differences.

In the first analysis, the errors were classified as "beginning", "end", or "middle", depending on whether they were in the first position, last position, or some other position. This procedure was adopted to be consistent with the scoring employed to analyze same-different judgments on the same letter strings. (See FRIEDRICH, WALKER & POSNER, 1985).

The Table 2 shows the percentage of correct letters as a function of position in the string. As can be seen, the pattern of results is quite clear. First, as might be expected, there were many more errors on nonwords than on words, $F(1,10) = 25.345$, $p<.001$. Secondly, there was a clear difference in the serial position curve for the three groups, with the normals showing a slight disadvantage at the end position, the Left Parietal patients showing a marked disadvantage at the end position, and the Right Parietal patients showing a marked disadvantage at the beginning position, $F(4,20) = 8.220$, $p<.001$. In addition, the position effects were more marked for nonwords than words: the interaction of wordness with position was significant, $F(2,20) = 11.875$, $p<.001$, as was the triple interaction, $F(4,20) = 9.055$, $p<.001$. (When the left and right parietal groups were compared without the normal group included in the analysis, all of the above comparisons were also significant with $p<.005$.)

INSERT TABLE 2

The data make clear that the left and right parietal groups show processing deficits that one would expect as a result of their attentional deficits for letter strings. However, since most of the asymmetry (and most of the errors) occurred with nonwords, we attempted a finer analysis of errors looking at words and nonwords separately.

In order to be able to evaluate the performance of individual subjects statistically, a different scoring procedure was used, in which the performance on each letter string was classified. An error was classified as a beginning error if: a) only the first and/or second letter was missed and no other letters missed; or b) if only the first N letters were missed for any N less than the length of the string. Conversely, an error was classified as an end error if a) only the last and/or next-to last letter was missed with no other letters missed; or b) only the last N letters were missed. All other errors were classified as other. Therefore, the response to each letter string was classified as a beginning error, an end error, an "other" error, or a correct response.

As can be seen in Table 3, there were large individual differences in performance. First, consider the patients with left parietal lesions. Evidence for an attentional deficit would be a greater number of end errors than beginning errors. All three made few errors on words, but made many more end errors than beginning errors on nonwords. However, the degree of deficit was markedly less for RF than for the other two. The problem in evaluating the performance of the left parietals, of course, is that normal subjects make more errors on the end than the beginning, presumably because of the order in which material is transferred into a verbal short-term memory buffer. Thus, one has to establish that the left parietal patients show a significantly greater tendency to produce end errors than normals. Moreover, since all three left parietals had language and/or short-term memory problems, one would have to ensure somehow that their greater tendency to produce end errors was not a verbal readout problem.

INSERT TABLE 3

Thus, the data from the left parietal patients is a bit equivocal. Since they all made more errors on the ends of nonwords than the normals (two of them making huge numbers of errors on the ends of nonwords), it appears that their attentional problem helped to interfere with their ability to process nonwords. However, we can't say for sure that their attentional problem was involved. What seems striking is that they made so few errors on words, even with their language and/or memory problems.

The data from right parietal patients is easier to interpret, since evidence for an attentional deficit for these patients would be a larger number of beginning errors than end errors, a difference not attributable to short-term memory readout. Two (FR and CU) appeared to have little attentional deficit on either words and nonwords, and in fact exhibited little attentional deficits on other laboratory tasks (they were included because their lesions involved parietal areas). Of the three right parietal patients with clear attentional problems, there appeared to be distinct performance differences. W.K. showed a pronounced attentional deficit when processing nonwords but performed almost perfectly on words. In contrast, C.W. showed a clear attentional deficit when processing both words and nonwords, although worse for nonwords. J.C., on the other hand, who had the most severe visual problem, showed a clear spatial deficit for nonwords, but showed no spatial deficit for words, even though he missed quite a few words.

We wish to make a brief digression to discuss the performance of RF. She made no errors on words, while making a significant number of end errors on nonwords. This was in spite of the fact that she reported all but two of the words by spelling them (i.e., just as she reported the nonwords). Furthermore, she could rarely pronounce the words correctly (although her attempted pronunciations resembled the correct ones) and often appeared not to know what they meant (she would often come up with inappropriate synonyms). Her data appear to illustrate that she possesses something like a logogen (since she can produce a spelling of the word better than for a nonword), but which has limited access to both name codes and meaning.

Experiment 2

Bedside Tests

Over all subjects in our previous experiment we found a very powerful word superiority effect. We also found clear evidence that patients with lesions of the left parietal lobe neglected the end of nonwords and patients with lesions of the right parietal lobe neglected the start of nonwords. However, the data of the left parietal patients is made less compelling by the fact that their pattern of performance is clearly a magnification of the normal tendency to have problems with the end of letter strings and could also involve their language and memory problems. Among our right parietal patients several found the test rather easy. These patients had all had very considerable time since the lesion and extensive training in attending the left side. Nonetheless, overall they showed a strong loss of information from the left side of nonwords but not of words. To further test our ideas we adopted a method briefly reported by BISIACH, MEREGALLI, & BERTI, (1985) in which patients were tested shortly after the lesion at bedside. This allowed us to study word and nonword reading among a population of patients with right sided lesions who had *not* had extensive rehabilitation.

Subjects

Only patients who made at least one error (either for words or for nonword) are used in this study. Ten patients were selected; their main clinical deficits and the data of CT scans are shown in Table 4. All of them presented a neglect of the left hemispace as seen by a clinical examination: drawing of a flower, copying of a house, completing the numbers of a clock, bisecting of lines, visual and tactile extinction when possible (no sensory deficit) and current behavior of neglecting the left hemispace or even of not (or less) using the left arm. Some of them had a left hemianopia.

INSERT TABLE 4

Methods and Procedure

Each of these patients were examined in their beds. They were approached from their right side and presented with a set of twenty cards either once or twice. (If twice, two different lists were used.) On half of the cards was printed an eight-letter word. Half of these words were compound words, the other half were non-compound words. On the other half of the cards was printed a non pronounceable nonword. They were given each card with the instruction to read what was written on the card: "read the word if it is a word or read and spell all the letters if it is not a word". They held the card in their hand and could place it wherever they wanted in their good hemifield. They had no limit to the time for reading each card and only their final response was considered.

The cards were 12.6 x 7.6 cm and words and nonwords were 10 cm long with each letter 1.2 x .9 cm. All letters were upper case and printed in black.

Rules of Scoring

Three scoring methods used in our experiments. Each stimulus was decomposed in three segments: in case of an eight-letter string segment I corresponds to the three first letters, segment II to the fourth and the fifth letters and segment III to the three last letters.

The first score counts the number of letters reported in each segment even if the letter was not in its correct position or even in the correct segment. This allows us to see if a certain letter was identified independently of the order. The score is the number of identified letters in each segment. The maximum score for the three segments in one stimulus are 3, 2 and 3, respectively.

In a third score only a complete segment (all the letters) in their correct place are counted as correct. The maximum score for each segment is 1. This allows to see if a group of letters was correctly identified and correctly ordered in the display.

We also calculated a second score. This counts only the letters reported in their correct place. If the response has eight letters the letter, to be counted, had to be in its exact position. If the response has less than eight letters a certain "laxity" is allowed as in Experiment 1. That is, if fewer letters were reported than were presented, we inserted blank spaces to give the subject the highest possible score. The maximum possible score for each segment is the same as the previous Method 1. Method 2 gave similar results to Method 1 and is thus not usually reported.

We also defined the Laterality Index (L.I.) defined by 100(R-L)/R+L in which R represents the total score of segment III (or right segment) for all the trials of an experiment, and L represents the total score of segment I (or left segment). If the L.I. is positive, it means that performance is best on the right. When the L.I. is negative, this means performance is best on the left. A null L.I. indicates no asymmetry.

Results

In most cases the patients pronounced the word but spelled the nonword. If they corrected the response we accepted the final choice. Corrections were mainly for nonwords. In case of words they did not correct their answer once they had produced a word, even a wrong one. Using the corrected responses thus reduces the actual differences between words and nonwords. Table 5 presents the results for the first three (segment 1) and last three (segment III) letters using the first and third scoring method.

INSERT TABLE 5

A two-way repeated measures ANOVA was computed with Stringtype (Words vs. Nonwords) and Segment (Left vs. Right) as factors, for the first and the third types of scoring. It is quite evident that overall performances were better for words than for nonwords and a significant effect for Stringtype emerged for the first score [$F(1,9) = 22.1$; $p<0.01$] as well as for the third score [$F(1,9) = 26.9$; $p<0.01$]. The effect of segment was also significant: for the first score [$F(1,9) = 11.1$; $p<0.05$] and for the third score [$F(1,9) = 14.9$; $p<0.01$]. Performances on the left segment were worse than performances on the right segment for nonwords and words, although there was a highly significant interaction Stringtype x Segment in the first score [$F(1,9) = 16.9$ [<0.01] and in the third score [$F(1,9) = 20.9$; $p<0.01$] showing that the asymmetry between the two segments (right better than left) was more important in case of nonwords. A one-way repeated measures ANOVA was computed with Segment (Left or Right) for words, then for nonwords. In both cases the effect of the side was significant: for the nonwords in the first score [$F(1,9) = 13.3$; $p<.01$] and in the third score [$F(1,9) = 18.0$; $p<.01$]; and for the words in the first score [$F(1,9) = 6.1$; $p<.05$] and in the third score [$F(1,9) = 5.3$; $p<.05$]. Also no significant difference was found between compound and non compound words, in the first [$F(1,9) = 2.6$; p n.s.] and the second score [$F(1,9) = 2.2$; p n.s.].

Thus, although there was an asymmetry (with neglect of the left side) of any type of stimulus, this asymmetry was much stronger in case of nonwords than in case of words. This was particularly striking because subjects usually responded quickly to the words and needed a much longer time for the nonwords. All the patients, even those with a mild or minor neglect, had a positive laterality index (right better than left) for nonwords (greater than 10% in seven cases for the third score). For the words however, only six patients had a positive laterality index (greater than 10% in three cases for the third score and in one case for the first score). Errors on words were made by those patients who had the strongest neglect in five cases, and by only one patient considered as having mild neglect: however, he was tested two days after his stroke.

Discussion

There was then a clear advantage of words over nonwords. Because of their familiarity, words are more recognizable than nonwords. However, our patients still had some problems with reading words. Errors for words were of three types. The first one is that they reported it letter-by-letter as if it were a nonword and misspelled it. This type of error may occur because the string was not seen as a word and because words and nonwords were mixed together. The other types of errors were those more commonly seen in patients with right hemisphere lesion. One is an attempt to pronounce the end of the word without making a meaningful unit out of it, the other is a production of a new word that has in common with the target only the end of the word and a few letters of the neglected segment.

The finding that these patients sometimes had problems with words may partly reflect the demands of the task in which words were mixed with nonwords and partly reflect the fact that they were frequently tested shortly after the lesion. These factors may also have contributed to the small spatial effect found with words. Nonetheless, the major result of this study is to confirm the interaction between words and nonwords found in Experiment 1. For these patients tested at bedside under conditions of more static reading there was much more neglect of the left side of nonwords than for words.

Experiment 3

Display factors producing extinction: a case study

Experiment 1 and 2 showed that extinction of nonwords for patients with right sided lesions is clearly greater than extinction with words. Previously Sieroff and Michel (in press) have shown that even short words show extinction when they are separated by a blank area centered on the fovea (bilateral simultaneous condition). In this experiment we studied one of the right lesioned patients of Experiment 1 (W.K.) who showed very clear sparing of words from extinction. We compare extinction caused by centered nonwords with that produced by bilateral words in order to determine the relative influence of these factors on extinction.

OBSERVATION: W.K.

W.K. is a 65 year old, right handed male. He had an accident forty years ago with an injury of his left eye. His vision is thus monocular. He presented episodes of left hemiplegia in 1975. A right carotid endarteriectomy was peformed but a new stroke with left hemiplegia occurred the same day. There was also, at the beginning, a left hemianopia and a neglect syndrome. When tested, the hemiplegia had partially recovered, the visual fields were normal on a Goldmann perimetry. He had minor and inconsistent problems of left neglect in every day life behavior. He also had difficulties in concentrating even in everyday events: forgetting what he has to buy in a store if it is too crowded, troubles in counting his money if a cashier is speaking to him. Reading was slow but normal for short passages; his only complaint in reading was a difficulty in remembering what he had read the day before in a book. He showed a visual extinction in clinical examination. When tested in the cueing experiment of POSNER, et al., (1984), he clearly showed the problem of disengagement of attention typical of parietal patients. The CT scan (1975) was in favor of a large right fronto-parietal ischemic lesion.

Methods and Procedure

In this experiment words and nonwords were presented on a video screen controlled by an Apple IIe microcomputer. They followed the presentation of a fixation symbol in the middle of the screen. The fixation symbol disappeared when the words were presented. The exposure duration of the fixation item was 500 ms. The exposure duration of the words or nonwords was 150 ms. We did not use a patterned mask because W.K. seemed affected and confused by its presence.

As in a previous experiment (see SIEROFF & MICHEL) there were three conditions of presentation of stimuli:

- unilateral condition: presentation of one three letter word or nonword in one hemifield; the first letter of the word in the right hemifield or last letter of the word in the left hemifield was one space from fixation;

- bilateral simultaneous condition: presentation of two three-letter words or nonwords, one in each hemifield, separated from each other by two spaces (each half of this display was equivalent to the previous condition);

- centered condition: presentation of an eight-letter centered word or non pronounceable nonword, thus four letters were presented in each hemifield.

Therefore, the visual angle of the extreme letter was exactly the same for each of these conditions. Although the distance between the eyes of the patient and the stimuli was not fixed, the patient was encouraged to not move his head. This visual angle was around 4 degrees + or - 1 degree, in each hemifield.

There were two experimental sessions a few weeks apart. The words and nonwords were blocked. (The number of trials in each condition is indicated in parenthesis in the ensuing results section.)

Ten normal subjects were also ran in a set of experiments in which all three conditions were present. Words and nonwords were randomly mixed.

Results

Results are shown in Table 6 with the methods 1 and 3.

INSERT TABLE 6

- Presentation of words:

In the unilateral condition (40 + 40 trials for each side) the right word is slightly better recognized than the left word, as was true of normal subjects. In the bilateral condition (80 + 80 trials) the results are fundamentally different from normal subjects: there was a clear advantage of the right hemifield with strong asymmetry, thus, a left extinction although he began his response with the left stimulus. Thus his attention deficit strongly influenced his performance in the bilateral condition. In the centered condition (80 + 120 trials) the results are similar to the normal subjects and there is no overall asymmetry between the two hemifields, for any of the three scores. Half of the centered words were compound words. There was no difference of asymmetry between them and the non compound words (Table 7). W.K., thus, is presenting what SIEROFF & MICHEL described previously as an inter-word extinction without an intra-word extinction.

INSERT TABLE 7

- Presentation of nonwords:

In the unilateral condition (32 + 24 trials for each side) there is an advantage of the right hemifield although it does not seem clearly different than the one shown by normal subjects. In the bilateral condition (48 + 48 trials), there is, as expected, a strong asymmetry with a laterality index of + 35 for score 1 (letters) and + 65 for score 3 (segments); this asymmetry is in the opposite direction of the one found in normals. In the centered condition, (48 + 60 trials), the asymmetry is quite strong for the third scoring (+ 60) and less for the first scoring (+ 10) but still larger than the one he showed in the unilateral condition and in the opposite direction than the one found in normals.

- Position of the stimulus:

We presented blocks of single eight-letter words or two three-letter words at varying distances from fixation. Consider the presentation of a single eight-letter word in the left visual field so that the final letter is at fixation. We found that the left segment was correct 42% of the time and the right segment 50%. We also presented blocks of two three-letter words in the same position as the single eight-letter word discussed above, but with a two-letter space between segments. The three letters on the left

(left most word) were reported correctly only 5% of the time while the three on the right were 45% correct. Thus, the presence of a gap in the bad field reduced performance on the first three letters by 30%.

Discussion

W.K. shows a strong extinction for bilateral stimuli whether words or nonwords but shows extinction for centered stimuli only when they were nonwords. The extinction for centered nonwords with sparing of words occurred for W.K. both under blocked presentation as in this study and intermixed conditions (Experiment 1). Moreover, varying the position of the stimuli did not appear to affect this finding. The current study was limited to eight-letter words but the sparing of centered words was similar to what was found in Experiment 1 with four to six-letter words and in previous work with other patients with 5-14 letter words (SIEROFF & MICHEL, in press). Thus, the general effects appear to hold up with differences in experimental method, word length, and string position.

The case of W.K. raises two important issues. First, is the word superiority effect due to guessing or to a genuine difference in the perception of words? Centered long words might be identified by seeing only the end and guessing the beginning, since there is a lot of redundancy in long words. Second, what happens to word superiority when there is a space between two words rather than a single word?

We ran one bilateral condition (on W.K.) in which we mixed words and nonwords. If bad performance on words on the left side is due to incorrect guessing, one would expect most errors to be reporting an incorrect word. Indeed, in the good visual hemifield most of the errors made on word stimuli were reports of an incorrect word. Errors in the good hemifield were words 52% of the time and nonwords only 37% (the remainder were omissions). However, in the bad visual hemifield only 39% of the errors were words, while 46% were nonwords and 15% omissions. Thus, W.K. is clearly not always assuming that all stimuli are words and guessing the closest word on the basis of the available letter information. It is possible he adopted a different guessing strategy for centered stimuli, but this seems far fetched. A second argument against guessing is that sparing of centered words from extinction also occurs for compound words. If W.K. only guessed based on his knowledge of the right half of the string one would get many errors on compound words consisting of only the word to the right of fixation or of a lawful but incorrect compound. These types of errors rarely occur.

The data of this experiment thus show that two factors are necessary to spare a letter string from extinction. First, it must be a word (or perhaps a pronounceable nonword) and second, it must be physically contiguous.

General Discussion

Current conceptions in neurophysiology include two cortical visual routes (UNGERLEIDER & MISHIN, 1982). The first involves pattern recognition, arises in primary visual cortex and extends through prestriate areas to the inferotemporal cortex (COWEY, 1985). The second relates to visual spatial attention and is more dorsal involving parietal cortex (MOUNTCASTLE, 1978; POSNER, WALKER, FRIEDRICH & RAFAL, 1984; WURTZ, GOLDBERG & ROBINSON, 1980).

The major purpose of the present experiments was to explore the relationship between the dorsal system for spatial attention and the ventral pattern recognition system for visual words. We did find large individual differences between patients. Most patients show strong extinction like effects for non words. Of the eight patients in Experiment 1 six showed significant differences favoring the ipsilesional side of non words. In Experiment 2 nine of the ten patients showed evidence of poor performance at the start of nonwords. On the other hand only one of our right parietal patients in Experiment 1 showed an extinction effect for words and only one patient in Experiment 2 showed a convincing problem with the start of words. In a much larger study SIEROFF & MICHEL (in press) found no right parietal patients who showed extinction of words. It seems safe to accept the generalization that for most subjects with a deficit in spatial attention there is a strong extinction for nonwords but little or no extinction for words. This result rules out two views of the relationship between the recogniton and attention systems. The first is that attention is a spotlight needed to register information at a visual location. For this view any location for which one finds a deficit in the letters of nonwords should show the same deficit for words. The second view is that a covert attention scan is needed to integrate letters into words. If this were so we would also expect words to show at least as strong an attention deficit as nonwords.

With these two views ruled out what kind of affect is left for attention? Two general ideas seem likely. Either of them might lead to several more specific models. The first suggests a role for attention in early visual information processing. Attention modulates the efficiency of registration of letters but is not an absolute necessity. If one couples this idea with an interactive parallel model for processing visual input (McCLELLAND & RUMELHART, 1983; PAPP, NEWSOME, MCDONALD, & SCHVANEVELDT, 1982; RUMELHART & McCLELLAND, 1982) it would predict that poorly registered letter information that is part of a word would activate stored lexical information which would, in turn, feed back and enhance the visibility of letter input. Thus, for words the higher level stored information would make up for the reduced letter input information thus, leading to clearer perception of letters when they are within words. A second class of models would see attention as unrelated to any of the early registration of letters or words. What attention does is to produce a serial readout of information into phonological, articulatory or semantic codes (MEWHORT, MARCHETTI, GURNSEY & CAMPBELL, 1984). Since a word can be treated as a single item it will require little attention to be read. Since in the case of nonwords, since there is no single unitized code, an elaborate serial scan requiring spatial attention is needed. In this view, attention is used for access to high level (non visual) lexical codes. It is a theory in which attention affects are late rather than early in the visual system.

These two hypotheses are not mutually exclusive. The late attention effect fits aspects of the data that suggest subjects do more poorly with more items. This is true when subjects spell nonwords but pronounce words. Since individual letters constitute many more items. It also fits well with the finding that words extinguish when presented on to the two fields simultaneously. However, some patients (e.g. RF) tend to spell words and nonwords yet they still show a word superiority affect. We find patients who give words as false alarms for nonwords, but these incorrect lexical items appear to show evidence of extinction of the early letters. Moreover, in our work with normals (SIEROFF & POSNER,) we find conditions in which spelled words seemed to behave like reported words rather than like spelled nonwords. This suggests that much of the difference in extinction for words and nonwords occurs whether a single or multiple higher level code is used and thus, argues against the late attention affect as a complete account of the data.

Regardless of the exact role that attention plays it appears that patients are unaware of the left side of nonwords but aware of the left side of words. Thus, whatever process produces the word nonword distinction must operate outside of attention. In one view, attention filters the evidence to the lexical network. On the other, it operates after the network but prior to any spatial scan of the items. If the system that operates on letter strings to produce their integrtion into words is the kind of lexical network postulated by MCCLELLAND and RUMELHART (1981) our data show that it operates within the visual system prior to or in conjunction with any spatial search of the items. This kind of interactive network require~ very intimate feedback between higher lexical levels and lower level letter levels. This requirement makes it reasonable to suppose such networks would have to involve neural systems where high levels of precise feedback are available. The known physiology of the prestriate occipital areas would suggest their involvement in such a network (COWEY, 1985). An occipital basis for the visual lexical network receives some support from recent studies of blood flow changes during visual word processing (PETERSEN, et al, 1986).

To enhance the interaction between anatomical and cognitive approaches to this problem it would be useful to see if spatial attention manipulations in normal persons could produce the interaction between words and nonwords that we have observed in patients. Our companion paper (SIEROFF & POSNER,) follows this strategy.

1. Experiments 1, 2 and 3 were performed at the Neuropsychology Lab. Good Samaritan Hospital, Portland, Oregon. The authors are grateful to Dr. O.S.M. Marin and to Dr. John Walker for their help in the study. Dr. Richard Ivry did much of the programming. The other experiments were performed at Washington University. The research was supported in part by Office of Naval Research Contract N-00014-86-0289 and by National Science Foundation Grant BNS-8609336.

2. Now at Laboratoire de Neuropsychologie, Hospital Neurologique, Lyon, France.

Benson, D.F. & Geschwind, N. The Alexias in Winken, P.J. & Bruyn, G.W. eds. Handbook of Clinical Neurology. Amsterdam: North Holland, 1969

Bisiach, E., Meregalli, S. & Berti, A. Mechanisms of production-control and belief-fixation in human visuo-spatial processing. Clinical evidence from hemispatial neglect. Eight Symposium on quantitative analysis of behavior. Harvard University, June, 1985

Coltheart, M., Davelaar, E., Jonasson, J.T. & Besner, D. Access to the internal lexicon. Dornic, S. Ed. Attention and Performance VI. Hillsdale, N.J.: Erlbaum, 1979

Covey, A. Aspects of cortical organization related to selective attention and selective impairments of visual perception: A tutorial review. In Posner, M.I. & Marin, O.S.M. eds. Attention and Performance XI. Hillsdale, N.J.: Erlbaum, 1985, 14-62.

Friedrich, F.J., Walker, J. & Posner, M.I. Effects of parietal lesions on visual matching: implications for reading errors. Cognitive Neuropsychology, 1985, 2, 253-264.

Kinsbourne, M. & Warrington, E.K. A disorder of simultaneous form perception. Brain, 85, 1962, 461-486.

LaBerge D.L. & Samuels, J. Toward a theory of automatic word processing in reading. Cognitive Psychology, 1974, 6, 293-323.

McClelland, J.L. & Rumelhart, D.E. An interactive activation model of context effects in letter perception. Psych. Rev. 1981, 88, 375-407.

Mewhort, D.J., Marchetti, F.M., Gurnsey, R. & Campbell, A.J. Information persistence: A dual-buffer model for initial visual processing. In Bouman, H. & Bouwhuis, D.G. (eds). Attention and Performance X. Hillsdale, N.J.: Erlbaum, 1984, 287-498.

Mountcastle, V.B. Brain systems for directed attention. J.R. Soc. of Med., 1978, 71, 14-27.

Papp, K.R., Newsome, S., McDonald, J.E. & Schvaneveldt, R.W. An activation verification model for letter and word recognition: the word superiority effect. Psych. Rev. 89, 1982, 573-594.

Pollatsek, A., Walker, J.A., Friedrich, F.J., & Posner, M.I. Spatial attention in reading words. Psychonomics Society. Boston, Nov. 1985.

Posner, M.I. Chronometric explorations of mind. Hillsdale, N.J.: Lawrence Erlbaum Assoc., 1978.

Posner, M.I., Walker, J.A., Friedrich, F.J., and Rafal, R.D. Effects of parietal lobe injury on covert orienting of visual attention. Journal of Neuroscience, 1984, 4:1863-1874.

Posner, M.I., Walker, J.A., Friedrich, F.J., and Rafal, R.D. How do the parietal lobes direct covert attention? Neuropsychologia, In press.

Rumelhart, D.E. & McClelland, J.L. An interactive activation model of context effect in letter perception: Part 2 The contextual enhancement effect and some tests and extensions of the model. Psych. Rev. 1982, 89, 60-94.

Sieroff, E. & Michel, F. Verbal visual extinction in right/left hemisphere lesion patients and the problems of lexical access. In press.

Ungerleider L.G. and Mishkin, M. Two cortical visual systems. In D.J. Ingle, M.A. Goodale and R.J.W. Mansfield (eds): Analysis of Visual Behavior. Cambridge, MA: The MIT Press, 549-586 (1982).

Warrington, E.K. & Shallice, T. Word form dyslexia. Brain. 103: 99-112, (1980).

Wurtz, R.H., Goldberg, M.E., and Robinson, E.L. Behavioral modulation of visual responses in the monkey. Prog. Psychobiol. Physiol. Psychol., 1980, 9: 43-83.

TABLE 1: PATIENTS TESTED IN THE READING OF WORDS AND NONWORDS

TACHISTOSCOPIC STUDY

	SEX	AGE	.......LESION......... NATURE	LOCATION	DELAY OF TEST (YEARS)	.......CLINICAL SIGNS....... NEGLECT SYNDROME ALERTNESS	OTHER FEATURES
Patients with left hemisphere lesion							
E.A.	F	55	Ischemic	Temporo-parietal	7	No clinical neglect	Peripheral reduction of the R visual field R hemihypoesthesia Conduction aphasia
R.F.	F	41	Traumatism	Post parieto-temporal	5	Minimal neglect?	R upper quadranopia Anomia Minimal dyslexia Memory deficit Mild R hemiparesis
R.C.	M	37	Ischemic	Fronto-parieto-temporal	2	Minimal neglect	Broca's aphasia Peripheral reduction of the R visual field R hemiplegia R hemihypoesthesia
Patients with right hemisphere lesion							
J.C. (left-handed)	M	61	Hematoma operated	Temporo-parieto-occipital	10	Minimal neglect	Peripheral reduction of the R visual field Minimal dyslexia Recovered aphasia Memory deficit
W.K.	M	65	Ischemic	Fronto-parietal	7	Mild neglect	No hemianopia L hemihypoesthesia L hemiparesis
F.R.	M	79	Ischemic	Parietal	2	Minimal neglect	No hemianopia L hemihypoesthesia L mild hemiparesis
C.U.	F	40	Tumor (resection)	Parietal	4	No clinical neglect	No hemianopia L hemihypoesthesia
C.W.	F	83	Ischemic	Fronto-parietal	6	Minimal neglect	No hemianopia L hemiplegia L hemihypoesthesia Depression

TABLE 2: PERCENTAGE OF CORRECT LETTERS AS A FUNCTION OF POSITION IN THE STRING FOR NORMALS AND RIGHT AND LEFT PARIETAL PATIENTS.

	Words			Nonwords		
	First Letter	Middle Letters	Last Letter	First Letter	Middle Letters	Last Letter
Normals						
Mean	100	100	100	97.7	96.0	92.4
Right Parietals						
Mean of all five	96.3	97.6	97.0	80.6	86.6	85.1
Mean of first 3	93.9	96.0	95.1	68.2	82.5	79.6
W.K.	99.1	99.6	99.1	85.8	96.3	93.4
C.W.	87.0	93.0	89.9	48.1	73.9	58.5
J.C.	95.5	95.5	96.2	70.8	79.3	86.8
F.R.	100	100	100	98.1	93.5	94.3
C.U.	100	100	100	100	92.2	92.5
Left Parietals						
Mean	100	99.8	98.1	94.7	86.7	51.9
E.A.	100	99.6	94.3	97.2	82.1	22.6
R.F.	100	100	100	94.3	95.1	86.8
R.C.	100	99.8	100	92.5	83.0	46.2

Note: R.C. was tested on nonwords by having him point to the appropriate letter in an alphabetically arranged series, since he had a severe letter naming deficit. On the first day, we merely asked him to report the first and last letters, while on the second day of testing, he was asked to report all the letters. The score for middle letters, accordingly, was only his score from the second day. All the other scores for R.C. are the averages of the two days. His score on the last letters, was somewhat depressed by asking him to report the middle ones as well. However, even on the first day, his error rate on the last letter was 41%.

TABLE 3

BEGINNING ERRORS VS. END ERRORS FOR SELECTED PATIENTS

	Words				Nonwords			
	Beginning Errors	End Errors	Other Errors	Beginning vs. End	Beginning Errors	End Errors	Other Errors	Beginning vs. End
Right Parietal								
W.K.	0	1	2	n.s.	21	3	20	$p < .001$
C.W.	11	2	19	$p < .025$	29	9	52	$p < .001$
J.C.	5	7	20	n.s.	22	12	62	$p < .10$
Left Parietal								
E.A.	0	6	3	$p < .05$	4	69	30	$p < .001$
R.F.	0	0	2	n.s.	2	10	14	$p < .05$
R.C.	0	0	3	n.s.	0	49	16	$p < .001$

Note: The total number of trials for each of the subjects was 106 both for words and for nonwords, with the exception of R.F. for whom the total number was 53 in each condition (she was only run in one session).

TABLE 4: PATIENTS TESTED IN THE READING OF WORDS AND NONWORDS BEDSIDE TEST

	SEX	AGE	...LESION .... NATURE	LOCATION	DELAY OF TEST (DAYS)	.......CLINICAL SIGNS............ NEGLECT SYNDROME ALERTNESS	OTHER FEATURES
M.A	F	42	Ischemic	Parietal	130	Mild Neglect Alert	No hemianopia L hemiparesia L hemihypoesthesia
W.C.	M	60	Hematoma	Occipito-parieto-temporal	60	Moderate neglect Episodes of confusion	Complete L hemianopia L hemihypoesthesia Diabetic retinopathy Memory deficit
G.H.	M	72	Hematoma	Parieto-occipital	20	Moderate neglect Slight confusion	Complete L hemianopia L hemihypoesthesia Memory deficit
F.K.	M	73	Ischemic	Parieto-occipital	30	Moderate neglect Mildly confused	Complete L hemianopia L hemianesthesia
J.K.	M	51	Ischemic	Fronto-temporo-parietal	17	Moderate neglect Variable alertness	L hemianopia L hemihypoesthesia L hemparesis
J.M.	M	61	Ischemic	Right middle cerebral artery	3	Minor neglect Alert	Peripheral restriction of the L visual field Mild L hemiparesis L tactile extinction
M.M.	M	59	Ischemic	Temporo-fronto-parietal+ old small left infarct	2	Minor neglect Alert	No hemianopia L hemiparesis L hemihypoesthesia
L.P.	F	86	Ischemic	Temporo-parietal (+ old right infarct	30	Moderate neglect Variable alertness	L hemianopia L hemihypoesthesia L hemiparesis
E.R.	F	66	Ischemic	Capsular	7	Minor neglect Alert	Incomplete L hemianopia L hemiparesis
W.W.	M	45	Ischemic	Capsular	28	Mild neglect	Transient Left hemiparesia

TABLE 5: PATIENTS PERFORMANCES IN READING EIGHT LETTER WORDS AND NONWORDS

The results are shown in percentage of correct response for the first or last segment (three first letters) and for the last or right segment (three last letters), in the first and third type of scoring.

SCORING METHOD 1

	Words			Nonwords		
	Left Segment	Middle Segment	Right Segment	Left Segment	Middle Segment	Right Segment
Mean	94.2	98.9	99.4	83.1	95.0	98.4
M.A.	100	100	100	96.7	100	100
W.C.	90	96.5	97.7	65.7	95	97.7
G.H.	93.3	100	100	83.3	97.5	98.3
F.K.	80	100	100	73.3	95	100
J.K.	90	95	100	56.7	90	100
J.M.	100	100	96.7	93.3	90	96.7
M.M.	93.3	100	100	93.3	100	100
L.P.	95	97.5	100	85	97.5	100
E.R.	100	100	100	90	95	93.3
W.W.	100	100	100	90	90	90

SCORING METHOD 3

	Words			Nonwords		
	Left Segment	Middle Segment	Right Segment	Left Segment	Middle Segment	Right Segment
Mean	90.8	97.8	98.3	59.2	85.8	94.5
M.A.	100	100	100	90	90	90
W.C.	73	93	93	37	63	80
G.H.	90	100	100	60	95	95
F.K.	80	100	100	20	80	100
J.K.	80	90	100	20	90	100
J.M.	100	100	90	80	80	90
M.M.	90	90	100	90	100	100
L.P.	95	95	100	65	90	100
E.R.	100	100	100	60	90	80
W.W.	100	100	100	70	80	100

Note: Patients L.P. and G.H. were tested with two lists of stimuli. W.C. with three. All others were tested with one list of 10 words and 10 nonwords.

TABLE 6:

TACHISTOSCOPIC PRESENTATION OF WORDS AND NONWORDS FOR W.K. AND NORMALS

Results are given in percentage of correct response and Laterality Index is calculated (L.I.). Standard deviation is in parenthesis for Normals.

First Scoring Method (letters)

Condition	Words				Nonwords			
	LVF	Fovea	RVF	L.I.	LVF	Fovea	RVF	L.I.
W.K.								
Unilateral	85.5		88.5	+1.5	74.0		82.7	+5.6
Bilateral	62.7		86.3	+15.8	38.2		80.0	+35.4
Centered	89.5	89.8	92.8	+1.9	59.5	70.9	73.0	+10.2
Normals								
Unilateral	96.9		98.5	+0.9	93.3		93.0	-0.2
	(3.2)		(2.1)	(2.2)	(5.3)		(5.2)	(2.5)
Bilateral	93.8		93.1	-0.4	79.4		74.6	-2.9
	(7.3)		(7.8)	(4.9)	(12.4)		(9.6)	(3.3)
Centered	98.7	99.0	99.4	+0.3	79.1	82.0	67.6	-7.9
	(1.6)	(1.4)	(0.7)	(0.9)	(7.4)	(7.5)	(8.1)	(7.4)

Third Scoring Method (segments)

Condition	Words				Nonwords			
	LVF	Fovea	RVF	L.I.	LVF	Fovea	RVF	L.I.
W.K.								
Unilateral	67.1		74.4	+5.2	30.0		48.1	+23.2
Bilateral	38.5		66.7	+26.8	7.4		34.7	+64.8
Centered	81.2	79.7	82.7	+0.9	7.6	24.1	30.4	+60.0
Normals								
Unilateral	90.6		95.6	+2.8	77.8		79.5	+1.1
	(8.8)		(6.4)	(6.6)	(15.3)		(15.5)	(9.6)
Bilateral	84.7		83.6	-0.5	45.0		29.7	-20.2
	(15.4)		(15.1)	(10.8)	(24.6)		(15.8)	(32.6)
Centered	97.2	97.5	97.8	+0.3	19.7	25.3	9.5	-43.0
	(3.4)	(0.9)	(2.3)	(1.7)	(16.2)	(12.4)	(11.3)	(51.3)

TABLE 7: RESULTS FOR COMPOUND AND NON COMPOUND WORDS FOR W.K.

	LVF	RVF	L.I.
Compound words	84.7	88.3	+2.1
Non Compound words	91.7	94.7	+1.6

Dr. Phillip L. Ackerman
University of Minnesota
Department of Psychology
Minneapolis, MN 55455

Dr. Beth Adelson
Department of Computer Science
Tufts University
Medford, MA 02155

Technical Director,
Army Human Engineering Lab
Aberdeen Proving Ground
MD 21005

Dr. Robert Ahlers
Code N711
Human Factors Laboratory
Naval Training Systems Center
Orlando, FL 32813

Dr. Ed Aiken
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. John Allen
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Earl A. Alluisi
HQ, AFHRL (AFSC)
Brooks AFB, TX 78235

Dr. James Anderson
Brown University
Center for Neural Science
Providence, RI 02912

Dr. Nancy S. Anderson
Department of Psychology
University of Maryland
College Park, MD 20742

Technical Director, ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Gary Aston-Jones
Department of Biology
New York University
1009 Main Bldg
Washington Square
New York, NY 10003

Dr. Alan Baddeley
Medical Research Council
Applied Psychology Unit
15 Chaucer Road
Cambridge CB2 2EF
ENGLAND

Dr. James Ballas
Georgetown University
Department of Psychology
Washington, DC 20057

Dr. Harold Bamford
National Science Foundation
1800 G Street, N.W.
Washington, DC 20550

Dr. Isaac Bejar
Educational Testing Service
Princeton, NJ 08450

Dr. Alvah Bittner
Naval Biodynamics Laboratory
New Orleans, LA 70189

Dr. John Blaha
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Sue Bogner
Army Research Institute
ATTN: PERI-SF
5001 Eisenhower Avenue
Alexandrai, VA 22333-5600

Dr. Gordon H. Bower
Department of Psychology
Stanford University
Stanford, CA 94306

Mr. Donald C. Burgy
General Physics Corp.
10650 Hickory Ridge Rd.
Columbia, MD 21044

Dr. Gail Carpenter
Northeastern University
Department of Mathematics, 504LA
360 Huntington Avenue
Boston, MA 02115

Dr. Pat Carpenter
Carnegie-Mellon University
Department of Psychology
Pittsburgh, PA 15213

Dr. Tyrone Cashman
American Society of
Cybernetics
3428 Fremont Ave. South
Minneapolis MN 55408

Dr. Alphonse Chapanis
8415 Bellona Lane
Suite 210
Buxton Towers
Baltimore, MD 21204

Dr. Paul R. Chatelier
OUSDRE
Pentagon
Washington, DC 20350-2000

Mr. Raymond E. Christal
AFHRL/MOE
Brooks AFB, TX 78235

Dr. David E. Clement
Department of Psychology
University of South Carolina
Columbia, SC 29208

Dr. Charles Clifton
Tobin Hall
Department of Psychology
University of
Massachusetts
Amherst, MA 01003

Assistant Chief of Staff
for Research, Development,
Test, and Evaluation
Naval Education and
Training Command (N-5)
NAS Pensacola, FL 32508

Dr. Michael Coles
University of Illinois
Department of Psychology
Champaign, IL 61820

Dr. Allan M. Collins
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Stanley Collyer
Office of Naval Technology
Code 222
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Leon Cooper
Brown University
Center for Neural Science
Providence, RI 02912

Dr. Lynn A. Cooper
Learning R&D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Phil Cunniff
Commanding Officer, Code 7522
Naval Undersea Warfare Engineering
Keyport, WA 98345

Brian Dallman
3400 TTW/TTGXS
Lowry AFB, CO 80230-5000

LT John Deaton
ONR Code 125
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. Stanley Deutsch
Committee on Human Factors
National Academy of Sciences
2101 Constitution Ave.
Washington, DC 20418

Dr. R. K. Dismukes
Associate Director for Life Sciences
AFOSR
Bolling AFB
Washington, DC 20332

Dr. Daniel Gopher
Industrial Engineering
& Management
TECHNION
Haifa 32000
ISRAEL

Dr. Sherrie Gott
AFHRL/MODJ
Brooks AFB, TX 78235

Jordan Grafman, Ph.D
2021 Lyttonsville Road
Silver Spring, MD 20910

Dr. Richard H. Granger
Department of Computer Science
University of California, Irvine
Irvine, CA 92717

Dr. Steven Grant
Department of Biology
New York University
1009 Main Bldg
Washington Square
New York, NY 10003

Dr. Wayne Gray
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Bert Green
Johns Hopkins University
Department of Psychology
Charles & 34th Street
Baltimore, MD 21218

Dr. James G. Greeno
University of California
Berkeley, CA 94720

Dr. William Greenough
University of Illinois
Department of Psychology
Champaign, IL 61820

Dr. Stephen Grossberg
Center for Adaptive Systems
Room 244
111 Cummington Street
Boston University
Boston, MA 02215

Dr. Muhammad K. Habib
University of North Carolina
Department of Biostatistics
Chapel Hill, NC 27514

Prof. Edward Haertel
School of Education
Stanford University
Stanford, CA 94305

Dr. Henry M. Halff
Halff Resources, Inc.
4918 33rd Road, North
Arlington, VA 22207

Dr. Nancy F. Halff
Halff Resources, Inc.
4918 33rd Road, North
Arlington, VA 22207

Dr. Ronald K. Hambleton
Prof. of Education & Psychology
University of Massachusetts
at Amherst
Hills House
Amherst, MA 01003

Dr. Cheryl Hamel
NTSC
Orlando, FL 32813

Mr. William Hartung
PEAM Product Manager
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Harold Hawkins
Office of Naval Research
Code 1142PT
800 N. Quincy Street
Arlington, VA 22217-5000

Prof. John R. Hayes
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Joan I. Heller
505 Haddon Road
Oakland, CA 94606

Dr. Stephanie Doan
Code 6021
Naval Air Development Center
Warminster, PA 18974-5000

Dr. Emanuel Donchin
University of Illinois
Department of Psychology
Champaign, IL 61820

Mr. Ralph Dusek
ARD Corporation
5457 Twins Knolls Road
Suite 400
Columbia, MD 21045

Dr. Ford Ebner
Brown University
Anatomy Department
Medical School
Providence, RI 02912

Dr. Jeffrey Elman
University of California,
San Diego
Department of Linguistics, C-008
La Jolla, CA 92093

Dr. William Epstein
University of Wisconsin
W. J. Brogden Psychology Bldg.
1202 W. Johnson Street
Madison, WI 53706

Dr. K. Anders Ericsson
University of Colorado
Department of Psychology
Boulder, CO 80309

Dr. Jerome A. Feldman
University of Rochester
Computer Science Department
Rochester, NY 14627

Dr. Paul Feltovich
Southern Illinois University
School of Medicine
Medical Education Department
P.O. Box 3926
Springfield, IL 62708

Dr. Craig I. Fields
ARPA
1400 Wilson Blvd.
Arlington, VA 22209

Dr. Gail R. Fleischaker
Margulis Lab
Biological Sci. Center
2 Cummington Street
Boston, MA 02215

Dr. Jane M. Flinn
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Michaela Gallagher
University of North Carolina
Department of Psychology
Chapel Hill, NC 27514

Dr. R. Edward Geiselman
Department of Psychology
University of California
Los Angeles, CA 90024

Dr. Don Gentner
Center for Human
Information Processing
University of California
La Jolla, CA 92093

Dr. Lee Giles
AFOSR
Bolling AFB
Washington, DC 20332

Dr. Eugene E. Gloye
Office of Naval Research
Detachment
1030 E. Green Street
Pasadena, CA 91106-2485

Dr. Joseph Goguen
Computer Science Laboratory
SRI International
333 Ravenswood Avenue
Menlo Park, CA 94025

Dr. Per Helmersen
University of Oslo
Department of Psychology
Box 1094
Oslo 3, NORWAY

Dr. Steven A. Hillyard
Department of Neurosciences
University of California,
San Diego
La Jolla, CA 92093

Dr. Geoffrey Hinton
Carnegie-Mellon University
Computer Science Department
Pittsburgh, PA 15213

Dr. Jim Hollan
Intelligent Systems Group
Institute for
Cognitive Science (C-015)
UCSD
La Jolla, CA 92093

Dr. John Holland
University of Michigan
2313 East Engineering
Ann Arbor, MI 48109

Dr. Melissa Holland
Army Research Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Keith Holyoak
University of Michigan
Human Performance Center
330 Packard Road
Ann Arbor, MI 48109

Dr. James Howard
Dept. of Psychology
Human Performance Laboratory
Catholic University of
America
Washington, DC 20064

Dr. Lloyd Humphreys
University of Illinois
Department of Psychology
603 East Daniel Street
Champaign, IL 61820

Dr. Earl Hunt
Department of Psychology
University of Washington
Seattle, WA 98105

Dr. Ed Hutchins
Intelligent Systems Group
Institute for
Cognitive Science (C-015)
UCSD
La Jolla, CA 92093

Dr. Alice Isen
Department of Psychology
University of Maryland
Catonsville, MD 21228

COL Dennis W. Jarvi
Commander
AFHRL
Brooks AFB, TX 78235-5601

Dr. Joseph E. Johnson
Assistant Dean for
Graduate Studies
College of Science and Mathematics
University of South Carolina
Columbia, SC 29208

CDR Tom Jones
ONR Code 125
800 N. Quincy Street
Arlington, VA 22217-5000

Mr. Daniel B. Jones
U.S. Nuclear Regulatory
Commission
Division of Human Factors Safety
Washington, DC 20555

Dr. Douglas H. Jones
Thatcher Jones Associates
P.O. Box 6640
10 Trafalgar Court
Lawrenceville, NJ 08648

Dr. Jane Jorgensen
University of Oslo
Institute of Psychology
Box 1094, Blindern
Oslo, NORWAY

Dr. Marcel Just
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Daniel Kahneman
The University of British Columbia
Department of Psychology
#154-2053 Main Mall
Vancouver, British Columbia
CANADA V6T 1Y7

Dr. Ruth Kanfer
University of Minnesota
Department of Psychology
Elliott Hall
75 E. River Road
Minneapolis, MN 55455

Dr. Demetrios Karis
Grumman Aerospace Corporation
MS C04-14
Bethpage, NY 11714

Dr. Milton S. Katz
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Steven W. Keele
Department of Psychology
University of Oregon
Eugene, OR 97403

Dr. Wendy Kellogg
IBM T. J. Watson Research Ctr.
P.O. Box 218
Yorktown Heights, NY 10598

Dr. Scott Kelso
Haskins Laboratories,
270 Crown Street
New Haven, CT 06510

Dr. Dennis Kibler
University of California
Department of Information
and Computer Science
Irvine, CA 92717

Dr. David Kieras
University of Michigan
Technical Communication
College of Engineering
1223 E. Engineering Building
Ann Arbor, MI 48109

Dr. David Klahr
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Ronald Knoll
Bell Laboratories
Murray Hill, NJ 07974

Dr. Sylvan Kornblum
University of Michigan
Mental Health Research Institute
205 Washtenaw Place
Ann Arbor, MI 48109

Dr. Stephen Kosslyn
Harvard University
1236 William James Hall
33 Kirkland St.
Cambridge, MA 02138

Dr. Kenneth Kotovsky
Department of Psychology
Community College of
Allegheny County
800 Allegheny Avenue
Pittsburgh, PA 15233

Dr. David H. Krantz
2 Washington Square Village
Apt. # 15J
New York, NY 10012

Dr. David R. Lambert
Naval Ocean Systems Center
Code 441T
271 Catalina Boulevard
San Diego, CA 92152-6800

Dr. Pat Langley
University of California
Department of Information
and Computer Science
Irvine, CA 92717

Dr. Marcy Lansman
University of North Carolina
The L. L. Thurstone Lab
Davie Hall 013A
Chapel Hill, NC 27514

Dr. Jill Larkin
Carnegie-Mellon University
Department of Psychology
Pittsburgh, PA 15213

Dr. Robert Lawler
Information Sciences, FRL
GTE Laboratories, Inc.
40 Sylvan Road
Waltham, MA [illegible]

Dr. Paul E. Lehner
PAR Technology Corp.
[illegible]
Suite [illegible]
[illegible]

Dr. Alan M. Lesgold
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA [illegible]

Dr. Jim Levin
Department of
[illegible] Psychology
[illegible] Building
[illegible] Street
Champaign, IL [illegible]

Dr. John Levine
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA [illegible]

Dr. Michael Levine
Educational Psychology
[illegible] Bldg.
[illegible]
[illegible]

Dr. Clayton Lewis
[illegible]
[illegible] Computer Science
[illegible]
[illegible]

Dr. Bob Lloyd
Dept. of Geography
University of South Carolina
Columbia, SC 29208

Dr. Frederic M. Lord
Educational Testing Service
Princeton, NJ 08541

Dr. Gary Lynch
University of California
Center for the Neurobiology of
Learning and Memory
Irvine, CA 92717

Dr. Don Lyon
P. O. Box 44
Higley, AZ 85236

Dr. William L. Maloy
Chief of Naval Education
and Training
Naval Air Station
Pensacola, FL 32508

Dr. Evans Mandes
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Dr. Sandra P. Marshall
Dept. of Psychology
San Diego State University
San Diego, CA 92182

Dr. Richard E. Mayer
Department of Psychology
University of California
Santa Barbara, CA 93106

Dr. James McBride
Psychological Corporation
c/o Harcourt, Brace,
Javanovich Inc.
1250 West 6th Street
San Diego, CA 92101

Dr. Jay McClelland
Department of Psychology
Carnegie-Mellon University
Pittsburgh, PA 15213

1986/11/10

Distribution List (Washington Univ./Posner

Dr. James L. McGaugh
Center for the Neurobiology
of Learning and Memory
University of California, Irvine
Irvine, CA 92717

Dr. Gail McKoon
CAS/Psychology
Northwestern University
1859 Sheridan Road
Kresge #230
Evanston, IL 60201

Dr. Joe McLachlan
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. James McMichael
Assistant for MPT Research,
Development, and Studies
OP 0187
Washington, DC 20370

Dr. Barbara Means
Human Resources
Research Organization
1100 South Washington
Alexandria, VA 22314

Dr. George A. Miller
Department of Psychology
Green Hall
Princeton University
Princeton, NJ 08540

Dr. Robert Mislevy
Educational Testing Service
Princeton, NJ 08541

Dr. William Montague
NPRDC Code 13
San Diego, CA 92152-6800

Mr. Melvin D. Montemerlo
NASA Headquarters
RTE-6
Washington, DC 20546

Dr. Tom Moran
Xerox PARC
3333 Coyote Hill Road
Palo Alto, CA 94304

Dr. Randy Mumaw
Program Manager
Training Research Division
HumRRO
1100 S. Washington
Alexandria, VA 22314

Dr. Allen Munro
Behavioral Technology
Laboratories - USC
1845 S. Elena Ave., 4th Floor
Redondo Beach, CA 90277

Dr. Richard E. Nisbett
University of Michigan
Institute for Social Research
Room 5261
Ann Arbor, MI 48109

Dr. Mary Jo Nissen
University of Minnesota
N218 Elliott Hall
Minneapolis, MN 55455

Deputy Technical Director
NPRDC Code 01A
San Diego, CA 92152-6800

Director, Training Laboratory,
NPRDC (Code 05)
San Diego, CA 92152-6800

Director, Manpower and Personnel
Laboratory,
NPRDC (Code 06)
San Diego, CA 92152-6800

Director, Human Factors
& Organizational Systems Lab,
NPRDC (Code 07)
San Diego, CA 92152-6800

Fleet Support Office,
NPRDC (Code 301)
San Diego, CA 92152-6800

Commanding Officer,
Naval Research Laboratory
Code 2627
Washington, DC 20390

Dr. Harold F. O'Neil, Jr.
School of Education - WPH 801
Department of Educational
Psychology & Technology
University of Southern California
Los Angeles, CA 90089-0031

Dr. Michael Oberlin
Naval Training Systems Center
Code [illegible]
Orlando, FL 32813-7100

Dr. Stellan Ohlsson
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Director, Research Programs,
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5000

Mathematics Group,
Office of Naval Research
Code 1111MA
800 North Quincy Street
Arlington, VA 22217-5000

Office of Naval Research,
Code 1133
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Research,
Code 1141NP
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Research,
Code 1142
800 N. Quincy St.
Arlington, VA 22217-5000

Office of Naval Research,
Code 1142EP
800 N. Quincy Street
Arlington, VA 22217-5000

Office of Naval Research,
Code 1142PT
800 N. Quincy Street
Arlington, VA 22217-5000
(6 Copies)

Director, Technology Programs,
Office of Naval Research
Code 12
800 North Quincy Street
Arlington, VA 22217-5000

Special Assistant for Marine
Corps Matters,
ONR Code 00MC
800 N. Quincy St.
Arlington, VA 22217-5000

Dr. Judith Orasanu
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Jesse Orlansky
Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311

Dr. Glenn Osga
NOSC, Code 441
San Diego, CA 92152-6800

Prof. Seymour Papert
20C-109
Massachusetts Institute
of Technology
Cambridge, MA 02139

Dr. Robert F. Pasnak
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Daira Paulson
Code 52 - Training Systems
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. James Paulson
Department of Psychology
Portland State University
P.O. Box 751
Portland, OR 97207

Dr. James W. Pellegrino
University of California,
Santa Barbara
Department of Psychology
Santa Barbara, CA 93106

Dr. Nancy Pennington
University of Chicago
Graduate School of Business
1101 E. 58th St.
Chicago, IL 60637

Dr. Ray Perez
ARI (PERI-II)
5001 Eisenhower Avenue
Alexandria, VA 2233

Dr. Steven Pinker
Department of Psychology
E10-018
M.I.T.
Cambridge, MA 02139

Dr. Martha Polson
Department of Psychology
Campus Box 346
University of Colorado
Boulder, CO 80309

Dr. Peter Polson
University of Colorado
Department of Psychology
Boulder, CO 80309

Dr. Steven E. Poltrock
MCC
9430 Research Blvd.
Echelon Bldg #1
Austin, TX 78759-6509

Dr. Michael I. Posner
Department of Neurology
Washington University
Medical School
St. Louis, MO 63110

Dr. Mary C. Potter
Department of Psychology
MIT (E-10-032)
Cambridge, MA 02139

Dr. Karl Pribram
Stanford University
Department of Psychology
Bldg. 4201 -- Jordan Hall
Stanford, CA 94305

Dr. Joseph Psotka
ATTN: PERI-1C
Army Research Institute
5001 Eisenhower Ave.
Alexandria, VA 22333

Dr. Mark D. Reckase
ACT
P. O. Box 168
Iowa City, IA 52243

Dr. Lynne Reder
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. James A. Reggia
University of Maryland
School of Medicine
Department of Neurology
22 South Greene Street
Baltimore, MD 21201

Dr. Fred Reif
Physics Department
University of California
Berkeley, CA 94720

Dr. Daniel Reisberg
Department of Psychology
New School for Social Research
65 Fifth Avenue
New York, NY 10003

Dr. Lauren Resnick
Learning R & D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15213

Mr. Raymond C. Sidorsky
Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Herbert A. Simon
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Zita M Simutis
Instructional Technology
Systems Area
ARI
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. H. Wallace Sinaiko
Manpower Research
and Advisory Services
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

Dr. Derek Sleeman
Stanford University
School of Education
Stanford, CA 94305

Dr. Edward E. Smith
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Linda B. Smith
Department of Psychology
Indiana University
Bloomington, IN 47405

Dr. Robert F. Smith
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA [illegible]

Dr. Alfred F. Smode
Senior Scientist
Code 7A
Naval Training Systems Center
Orlando, FL [illegible]

Dr. Richard E. Snow
Department of Psychology
Stanford University
Stanford, CA 94306

Dr. Elliot Soloway
Yale University
Computer Science Department
P.O. Box 2158
New Haven, CT 06520

Dr. Kathryn T. Spoehr
Brown University
Department of Psychology
Providence, RI 02912

James J. Staszewski
Research Associate
Carnegie-Mellon University
Department of Psychology
Schenley Park
Pittsburgh, PA 15213

Dr. Ted Steinke
Dept. of Geography
University of South Carolina
Columbia, SC 29208

Dr. Robert Sternberg
Department of Psychology
Yale University
Box 11A, Yale Station
New Haven, CT 06520

Dr. Saul Sternberg
University of Pennsylvania
Department of Psychology
3815 Walnut Street
Philadelphia, PA 19104

Dr. Albert Stevens
Bolt Beranek & Newman, Inc.
10 Moulton St.
Cambridge, MA 02238

Dr. Paul J. Sticha
Senior Staff Scientist
Training Research Division
HumRRO
1100 S. Washington
Alexandria, VA 22314

1986/11/10

Distribution List (Washington Univ./Posner)

Dr. Gil Ricard
Mail Stop C04-14
Grumman Aerospace Corp.
Bethpage, NY 11714

Dr. Mary S. Riley
Program in Cognitive Science
Center for Human Information
Processing
University of California
La Jolla, CA 92093

Dr. Andrew M. Rose
American Institutes
for Research
1055 Thomas Jefferson St., NW
Washington, DC 20007

Dr. Ernst Z. Rothkopf
AT&T Bell Laboratories
Room 2D-456
600 Mountain Avenue
Murray Hill, NJ 07974

Dr. William B. Rouse
Search Technology, Inc.
25-b Technology Park/Atlanta
Norcross, GA 30092

Dr. Donald Rubin
Statistics Department
Science Center, Room 608
1 Oxford Street
Harvard University
Cambridge, MA 02138

Dr. David Rumelhart
Center for Human
Information Processing
Univ. of California
La Jolla, CA 92093

Dr. E. L. Saltzman
Haskins Laboratories
270 Crown Street
New Haven, CT 06510

Dr. Fumiko Samejima
Department of Psychology
University of Tennessee
Knoxville, TN 37916

Dr. Michael J. Samet
Perceptronics, Inc
6271 Variel Avenue
Woodland Hills, CA 91364

Dr. Arthur Samuel
Yale University
Department of Psychology
Box 11A, Yale Station
New Haven, CT 06520

Dr. Roger Schank
Yale University
Computer Science Department
P.O. Box 2158
New Haven, CT 06520

Dr. Walter Schneider
Learning R&D Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Dr. Janet Schofield
Learning R&D Center
University of Pittsburgh
Pittsburgh, PA 15260

Dr. Hans-Willi Schroiff
Institut fuer Psychologie
der RWTH Aachen
Jaegerstrasse zwischen 17 u. 19
5100 Aachen
WEST GERMANY

Dr. Robert J. Seidel
US Army Research Institute
5001 Eisenhower Ave.
Alexandria, VA 22333

Dr. Michael G. Shafto
ONR Code 1142PT
800 N. Quincy Street
Arlington, VA 22217-5000

Dr. T. B. Sheridan
Dept. of Mechanical Engineering
MIT
Cambridge, MA 02139

Cdr Michael Suman, PD 303
Naval Training Systems Center
Code N51, Comptroller
Orlando, FL 32813

Dr. Steve Suomi
NIH Bldg. 31
Room B2B-15
Bethesda, MD 20205

Dr. Hariharan Swaminathan
Laboratory of Psychometric and
Evaluation Research
School of Education
University of Massachusetts
Amherst, MA 01003

Mr. Brad Sympson
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. John Tangney
AFOSR/NL
Bolling AFB, DC 20332

Dr. Kikumi Tatsuoka
CERL
252 Engineering Research
Laboratory
Urbana, IL 61801

Dr. Maurice Tatsuoka
220 Education Bldg
1310 S. Sixth St.
Champaign, IL 61820

Dr. Richard F. Thompson
Stanford University
Department of Psychology
Bldg. 4201 -- Jordan Hall
Stanford, CA 94305

Dr. Martin A. Tolcott
3001 Veazey Terr., N.W.
Apt. 1617
Washington, DC 20008

Dr. Douglas Towne
Behavioral Technology Labs
1845 S. Elena Ave.
Redondo Beach, CA 90277

Dr. Robert Tsutakawa
University of Missouri
Department of Statistics
222 Math. Sciences Bldg.
Columbia, MO 65211

Dr. Michael T. Turvey
Haskins Laboratories
270 Crown Street
New Haven, CT 06510

Dr. Amos Tversky
Stanford University
Dept. of Psychology
Stanford, CA 94305

Dr. James Tweeddale
Technical Director
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Zita E. Tyer
Department of Psychology
George Mason University
4400 University Drive
Fairfax, VA 22030

Headquarters, U. S. Marine Corps
Code MPI-20
Washington, DC 20380

Dr. David Vale
Assessment Systems Corp.
2233 University Avenue
Suite 310
St. Paul, MN 55114

Dr. Kurt Van Lehn
Department of Psychology
Carnegie-Mellon University
Schenley Park
Pittsburgh, PA 15213

Dr. Jerry Vogt
Navy Personnel R&D Center
Code 51
San Diego, CA 92152-6800

Dr. Howard Wainer
Division of Psychological Studies
Educational Testing Service
Princeton, NJ 08541

Dr. Beth Warren
Bolt Beranek & Newman, Inc.
50 Moulton Street
Cambridge, MA 02138

Dr. Norman M. Weinberger
University of California
Center for the Neurobiology
of Learning and Memory
Irvine, CA 92717

Dr. David J. Weiss
N660 Elliott Hall
University of Minnesota
75 E. River Road
Minneapolis, MN 55455

Dr. Shih-Sung Wen
Jackson State University
1325 J. R. Lynch Street
Jackson, MS 39217

Dr. Keith T. Wescourt
FMC Corporation
Central Engineering Labs
1185 Coleman Ave., Box 580
Santa Clara, CA 95052

Dr. Douglas Wetzel
Code 12
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Barbara White
Bolt Beranek & Newman, Inc.
10 Moulton Street
Cambridge, MA 02238

Dr. Barry Whitsel
University of North Carolina
Department of Physiology
Medical School
Chapel Hill, NC 27514

Dr. Christopher Wickens
Department of Psychology
University of Illinois
Champaign, IL 61820

Dr. Heather Wild
Naval Air Development
Center
Code 6021
Warminster, PA 18974-5000

Dr. Robert A. Wisher
U.S. Army Institute for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, VA 22333

Dr. Martin F. Wiskoff
Navy Personnel R & D Center
San Diego, CA 92152-6800

Mr. John H. Wolfe
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. George Wong
Biostatistics Laboratory
Memorial Sloan-Kettering
Cancer Center
1275 York Avenue
New York, NY 10021

Dr. Donald Woodward
Office of Naval Research
Code 1141NP
800 North Quincy Street
Arlington, VA 22217-5000

Dr. Wallace Wulfeck, III
Navy Personnel R&D Center
San Diego, CA 92152-6800

Dr. Joe Yasatuke
AFHRL/LRT
Lowry AFB, CO 80230

Mr. Carl York
System Development Foundation
181 Lytton Avenue
Suite 210
Palo Alto, CA 94301

Dr. Joseph L. Young
Memory & Cognitive
Processes
National Science Foundation
Washington, DC 20550

1986/11/10

Distribution List (Washington Univ./Posner)

Dr. Steven Zornetzer
Office of Naval Research
Code 1140
800 N. Quincy St.
Arlington, VA 22217-5000

Dr. Michael J. Zyda
Naval Postgraduate School
Code 52CK
Monterey, CA 93943-5100

END
4-87
DTIC